Appendix C Elasticity Calculations

C.1 Fuel Price Elasticities

The prices and price projections for coal and natural gas used in ReEDS are subject to demand elasticities. Baseline price and fuel demand projections are inputs to the model, and between optimizations the computed usage from the previous period is compared with the latest forecast for that year to update both price and usage projections. The updated prices are then used in the following year's optimization (and the updated forecasts are then compared to the outcome of that optimization).

The baseline price and fuel demand projections and the elasticities are all based on the AEO reference scenario and one or more other AEO scenarios (e.g. carbon tax, high renewables). By this method the baseline projections and elasticities are self-consistent. Short-term and long-term elasticities differ to account for varying flexibility of price compensation—i.e. short-term behavioral adjustments vs. long-term infrastructure improvements.

Equations for the two fuels are identical, so only the calculations for natural gas will be shown below. The adjusted fuel price forecast, $GasCost_{y,y_o,r}$ (the first subscript, y, varies over the set of time-periods 2006-2050 while the second subscript, y_o, marks the current time-period; so the subscripts indicate that this is the forecast for natural gas price in year y as forecast in y_o), is calculated by applying short-term and long-term multipliers, $Delta\_gasprice_{y_o,term}$, to the fuel price forecast determined for the preceeding period. ReEDS tracks a fuel price forecast for each NERC region, but only a national elasticity.

$$GasCost_{y,y_o,r} = \begin{cases} (1 + Delta\_gasprice_{y_o,st}) \cdot GasCost_{y,y_o-1,r} & \text{if } y_o \le y \le y_o + shortterm, \\ (1 + Delta\_gasprice_{y_o,lt}) \cdot GasCost_{y,y_o-1,r} & \text{if } y > y_o + shortterm. \end{cases}$$

where the percentage change for the gas price has been calculated as (actual - expected)/(expected):

$$Delta\_gasprice_{y_o,term} = gasprice\_elas_{term} \cdot \left(\frac{gas\_usage_{y_o-1} - Fcast\_Gasusage\_elec_{y_o-1,y_o-1}}{Fcast\_Gasusage\_elec_{y_o-1,y_o-1} + Fcast\_Gasusage\_nonelec_{y_o-1}} \right)$$

where

$gasprice\_elas_{term}$ are short-term and long-term elasticity coefficients—percentage change in price for each one percent change in demand.

$gas\_usage_{y_o-1}$ is the actual demand in the previous time-slice, $y_o - 1$.

$Fcast\_Gasusage\_elec_{y_o-1,y_o-1}$ is the forecasted demand for the previous time-slice, $y_o - 1$ as forecast in the previous time-slice, $y_o - 1$.

$Fcast\_Gasusage\_nonelec_{y_o-1}$ is the demand outside the electric sector for the previous time-slice, $y_o - 1$. Non-electric demand is not included in ReEDS and is not adjusted from the baseline forecast.

The new demand forecast, likewise, is an adjustment of the previous year's demand forecast, again calculated from (actual - expected)/(expected). By adjusting the price and demand forecasts simultaneously, ReEDS keeps the two trajectories paired: a given year's price trajectory is matched with the corresponding usage forecast; when the demand varies from that forecast, both trajectories are recalculated based on the new information.

$$Fcast\_gasusage\_elec_{y,y_o} = Fcast\_gasusage\_elec_{y,y_o-1} \cdot \left(\frac{gas\_usage_{y_o-1}}{Fcast\_gasusage\_elec_{y_o-1,y_o-1}} \right)$$

Note that all updates to the fuel price and demand forecasts only impact subsequent years of simulation because ReEDS solves every two year period individually and sequentially.

C.2 Demand Elasticities

Electricity demand, as exemplified by the average and peak load parameters, $L_{n,m}$ and P_n, respectively, in ReEDS is subject to price elasticity. There is a regional internal electricity price calculation in ReEDS that adjusts the load growth forecast based on changes in electricity price.

The elasticity calculations are inverted compared to the fuel price elasticities—because here demand is adjusted based on price instead of price being adjusted because of changes in demand—but are otherwise very similar. The load forecasts are adjusted from the previous year's forecast via short-term and long-term multipliers, $Delta\_demand_{r,term}$, which are computed based on differences between expected and actual electricity prices. Where the fuel price elasticities were uniform nationally, electricity demand elasticities can vary among NERC regions. The demand elasticities were determined based on differences between alternative AEO scenarios (e.g. reference case vs. carbon tax or high fuel prices) and so are consistent with the baseline demand trajectory. As with the fuel price elasticities, these calculations are completed between optimizations, using results from the previous time period's solution to generate data that is used in the next time period.

$$L_{y,y_o,n,m} = \begin{cases} (1 + Delta\_demand_{y_o,n\in r,st}) \cdot L_{y,y_o-1,n,m} & \text{if } y_o \le y \le y_o + shortterm, \\ (1 + Delta\_demand_{y_o,n\in r,lt}) \cdot L_{y,y_o-1,n,m} & \text{if } y > y_o + shortterm. \end{cases}$$

$$P_{y,y_o,n} = \begin{cases} (1 + Delta\_demand_{y_o,n\in r,st}) \cdot P_{y,y_o-1,n} & \text{if } y_o \le y \le y_o + shortterm, \\ (1 + Delta\_demand_{y_o,n\in r,lt}) \cdot P_{y,y_o-1,n} & \text{if } y > y_o + shortterm. \end{cases}$$

where the multipliers are calculated, again, as (actual - expected)/(expected):

$$Delta\_demand_{y_o,r,term} = demand\_elas_{r,term} \cdot \left(\frac{elec\_price_{y_o-1,r} - Fcast\_elec\_price_{y_o-1,y_o-1,r}}{Fcast\_elec\_price_{y_o-1,y_o-1,r}} \right)$$

where

$demand\_elas_{r,term}$ are short-term and long-term elasticity coefficients—percentage change in price for each one percent change in demand—for NERC region r.

$elec\_price_{y_o-1,r}$ is the regional average electricity price computed in the previous time-slice, $y_o - 1$.

$Fcast\_elec\_price_{y_o-1,y_o-1,r}$ is the regional average electricity price for the previous time-slice, $y_o - 1$ as forecast in the previous time-slice, $y_o - 1$.